Efficacy of a New Four-Lumen Multi-Oriface Wound Catheter

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Abstract

There are few studies to investigate the configuration of the wound catheter. We developed a new catheter and compared our new four-lumen multi-orifice catheter with a commercially available single-lumen multi-orifice catheter in regard to local anesthetic diffusion from the catheter using the dye infusion model in rabbit muscles. A new catheter was made to have a 1 mm external diameter divided into four equal lumens inside. It has four holes of 0.1 mm in diameter, one hole in each lumen with an interval of 20 mm and 90 degrees angle starting at 10 mm from the tip of the catheter. As a single-lumen multi-orifice catheter, the Soaker catheter™ (I Flow, lake Forest, CA, USA) was cut to have the same length (70 mm) with holes as our new catheter and the tip was melted to close. Each catheter was put into an incised muscle of euthanasized rabbit. A blue dye was infused at a rate of 1 or 4 ml/h for 15 minutes. Diffusion of dye was visually compared between the catheters. Dye was homogenously diffused with a new catheter, but not with the Soaker catheter at both 1 ml/h and 4 ml/h, especially at 1 ml/h.

Keywords

Postoperative Pain; Wound Infiltration

Introduction

The number of patients who take anticoagulants is increasing. For such patients, an epidural catheter is contraindicated. Local anesthetic infusion for a wound or peri-neural catheter is available for patients with anticoagulants. Administration of local anesthetics at wound seems to be a reasonable approach to decrease afferent nociceptive input from the site of surgical pain. Local anesthetic can inhibit local inflammatory response to injury, which sensitizes nociceptive receptors and contributes to pain and hyperalgesia (Rawal,2011).

There are many studies regarding the effects of administration of local anesthetics via a wound or peri-neural catheter. Some studies showed the improvement of postoperative analgesia by local anesthetic continuous wound infiltration (Chester et al., 1989; rackelboom et al., 2010) whereas others did not have positive effects (Gibbs et al., 1988; Baulig et al., 2011).

Many factors should be considered to have effective local anesthetic infusion, i.e. which local anesthetic used, dose and concentration of local anesthetic, where to put the catheter, the catheter configuration, etc.

The Soaker catheter™ (I Flow, Lake Forest, CA, USA) is a single lumen multi-orifice catheter that is the most often used as a wound catheter. However, there is no standard catheter proven to deliver the effective infusion of local anesthetics. We developed a new four-lumen multi-orifice wound catheter, which is expected to deliver uniform infiltration of local anesthetic, and the present study was performed to compare diffusion from the catheter between our new catheter and the Soaker catheter using dye diffusion in the rabbit muscles.

Materials and Methods

A new four-lumen multi-orifice wound catheter was made to have a 1 mm external diameter divided into four equal lumens inside. It has four holes of 0.1 mm in diameter, one hole in each lumen with an interval of 20 mm and 90 degrees angle starting at 10 mm from the tip of the catheter. The last hole was 70 mm from the tip of the catheter (Figure 1). As a commercially available single-lumen multi-orifice wound catheter, the Soaker catheter™ was used. It has a single lumen with holes of 0.15 mm in diameter and an interval of 4 mm and 90 degrees angle (Figure 1). This catheter has 60 holes in 250 mm length originally, but it was cut to have the same length (70 mm) with holes as our new catheter, and the tip was melted to close. After the approval of the review board of research committee of the laboratory, each catheter was put into an incised muscle of euthanasized rabbit. A blue dye was infused at a rate of 1 or 4 ml/h for 15 minutes. Diffusion of dye was optically compared between the catheters. Two muscles were used for each infusion rate of each

catheter.

Results

Dye was homogenously diffused with the new catheter, but not with the Soaker catheter at both 1 ml/h and 4 ml/h, especially at 1 ml/h (Figure 2).

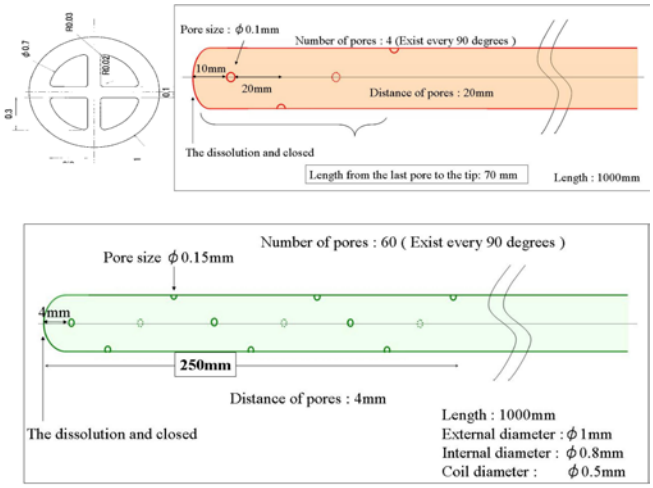

FIG. 1 SCHEMA OF THE CATHETER

The upper is our new four-lumen multi-oriface catheter. The lower is the Soaker catheter™ (single-lumen multi-oriface catheter).

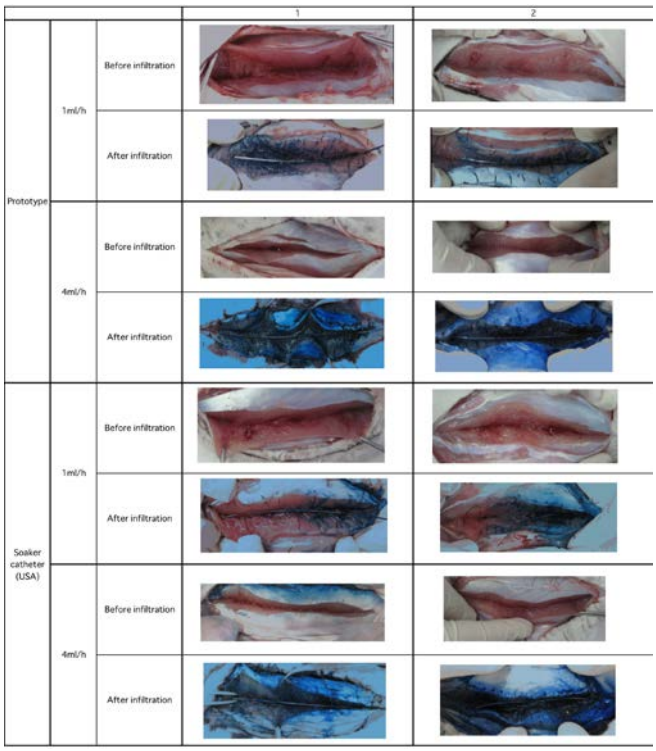

FIG. 2 DYE DIFFUSION

Dye diffusion from the catheter was shown. Each muscle (1 and 2) was tested at 1 and 4 ml/h with each catheter. The prototype (our new catheter) showed more homogenous diffusion of the dye, especially at 1 ml/h.

Discussion

We developed a new wound catheter that has four lumens inside to separate the holes opened with 90 degrees angles. It was expected that only one hole in each lumen could give the equal flow to every holes. Therefore, our new catheter may be able to infiltrate local anesthetic more homogenously than a single-lumen multi-holes catheter. The present results confirmed our hypothesis at both low infusion rate (1 ml/h) and high infusion rate (4 ml/h), especially at low infusion rate. We used two different infusion rate 1 ml/h and 4 ml/h because almost all of the previous clinical studies used infusion rate $\leqslant$ 4 ml/h (Baulig et al., 2011; Fredrickson et al., 2011, Polglase et al., 2007).

Local anesthetic continuous wound infiltration improved pain scores and decreased opioid requirement (Chester et al., 1989), whereas another study showed that saline was as effective as local anesthetic (Gibbs et al., 1988). Pain intensity was lower and rescue morphine consumption was smaller in patients undergoing obstetric and gynecological surgery, but no other benefits of wound infiltration of local anesthetic were found in the meta-analysis (Gupta et al., 2011). Subcutaneous local anesthetic infiltration may not improve postoperative pain, although it has an impact on opioid consumption (Givens et al., 2002). Continuous infiltration of ropivacaine into the pre-peritoneal layer using the Soaker catheter did not reduce pain sensation and opiate consumption (Baurig et al., 2011). From these reports, effects of local anesthetic infusion via a wound catheter have some limits. One of the determinants of the effects of wound infusion of local anesthetic is the location of the catheter. There is no universal agreement where wound catheters should be placed to achieve best pain relief. In patients undergoing abdominal hysterectomy, local anesthetic wound infusion above the fascia provided better postoperative analgesia than the infusion below the fascia (Hafizoglu et al., 2008). Continuous wound infusion below the fascia by multi-holes catheter resulted in significantly reduced pain at rest and total postoperative morphine consumption compared with wound administration above the fascia (Rackelboom et al., 2010). In the present study, the catheter was put only in extracted muscles, therefore, the difference in diffusion among various locations of the catheter was excluded from discussion.

Another determinant of peri-neural or wound catheter success is configuration of the catheter. There are few studies of catheter configuration. Anderson et al. (2010) found that wound spread of a bolus injection through a 15 cm multi-holes catheter was similar to a

triple-orifice epidural catheter when placed subfascially following total hip arthroplasty. Fredrickson et al.(2011) investigated the effects of catheter orifice configuration and found that multi-orifice catheters provided better block than end-hole catheters in interscalene block. This finding is consistent with the studies of epidural catheters (Dickson et al., 1997). However, the benefit of the multi-orifice catheters may be available only when used by intermittent bolus administration of local anesthetics, not by continuous infusion. Flow from multi-orifice catheter shown depended on the flow rate; below 80 mL/h, multi-orifice catheter function like single-orifice catheters (Fegley et al., 2008). From these reports, multi-orifice catheter is better than single-orifice catheter for bolus injection but not for continuous infusion.

There is only one study to compare different size of the catheter. Campolo et al. (2011) reported that catheters with small size holes (34.9 – 70.04 μm) distributed the flow more homogenously than those with large size holes (282.56 – 360.24 μm). Our new catheter has smaller holes than the Soaker catheter. That might be one of the reasons for more homogenous diffusion with our new catheter than the Soaker catheter.

Our present study suggested that a four-lumen catheter with holes of 0.1 mm in diameter was better than a single-lumen catheter with holes of 0.15 mm in diameter to provide homogenous distribution of continuously infused local anesthetics. However, the limit of our study is that our study used extracted muscles, not in vivo. Dye was not absorbed into the vessels, and tissue pressure around the catheter was different from a living body. Therefore, further in vivo studies are necessary to confirm the benefit of a new four-lumen multi-orifice catheter. In addition, to confirm the benefit of four-lumen catheter, we need to compare the catheters with same size holes.

Conclusions

We developed a new four-lumen multi-orifice wound catheter with holes of 0.1 mm in diameter. That catheter induced more homogenous dye diffusion than the single-lumen catheter (Soaker catheter) with holes of 0.15 mm in diameter at infusion rate$\leqslant$4 ml/h.

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REFERENCES

Andersen, L.ϕ., Kristensen, B.B., Madsen, J.L., Otte, K.S., Husted, H., and Kehlet, H., "Wound Spread of Radiolabeled Saline with Multi-Versus Few-Hole Catheters." Regiona Anesthesia and Pain Medicine 35 (2010): 200-2.

Baulig, W., Maurer, K., Theusinger, O.M., Hinselmann, V., Baulig, B., Spahn, D.R., Zalunardo, M.P., "Continuous Elastomeric Pump-Based Ropivacaine Wound Instillation after Open Abdominal Aortic Surgery: How Reliable is the Technique?" The Heart Surgery Forum #2010-1089 14 (2011): E51-8.

Campolo, M., Molin, D., Rawal, N., Soldati, A., "Protocols to Compare Infusion Distribution of Wound Catheters." Medical Engineering & Physics 2011 PMID 21908225

Chester, J.F., Ravindranath, K., White, B.D., Shanahan, D., Taylor, R.S., Lloyd-Williams, K., "Wound Perfusion with Bupivacaine: Objective Evidence for Efficacy in post-Operative Pain Relief." Annals of Royal College of Surgeons of England 71 (1989): 394-6.

Dickson, M.A., Moores, C., McClure, J.H. "Comparison of Single, End-Holed and Multi-Orifice Extradural Catheters when Used for Continuous Infusion of Local Anesthetic during Labour." British Journal of Anaesthesia (79) 1997: 297-300.

Fegley, A.J., Lerman, J., Wissler, R., "Epidural Multiorifice Catheters Function as Single-Orifice Catheters: An in Vitro Study." Anesthesia & Analgesia 107 (2008): 1079-81.

Fredrickson, M.J., Ball, C.M., Dalgleish, A.J., "Catheter orifice configuration influences the effectiveness of continuous peripheral nerve blockade." Regional Anesthesia and Pain Medicine 36 (2011): 470-5.

Gibbs, P., Puroshotham, A., Auld, C., Cushieri, R.J., "Continuous Wound Perfusion with Bupivacaine for Postoperative Wound Pain." British Journal of Surgery 75 (1988): 923-4.

Givens, A., Lipscomb, G., Meyer, N., "A randomized Trial of Post-Operative Wound Irrigation with Local Anesthetic for Pain after Cesarean Delivery." American Journal of Obstetrics and Gynecology 186 (2002): 1188-91.

Gupta, A., Favaios, S., Perniola, A., Magnuson, A., Berggren, L., "A Meta-Analysis of the Efficacy of Wound Catheters for Post-Operative Pain Management." Acta Anaesthesiologica Scandinavica 55 (2011): 785-96.

Hafizoglu, M.C., Katircioglu, K., Ozkalkanli, M.Y., Savaci, S., "Bupivacaine Infusion above or below the Fascia for Postoperative Pain Treatment after Abdominal Hysterectomy." Anesthesia & Analgesia 107 (2008): 2068-72.

Polglase, A.L., McMurrick, P.J., Simpson, P.J.B., Wale, R.J., Carne, P.W.G., Johnson, W., Chee, J., Ooi, C.W., Chong, J.W., Kingsland, S.R., Buchbinder, R., "Continuous Wound Infusion of Local Anesthetic for the Control of Pain after Elective Abdominal Colorectal Surgery." Diseases of the Colon and Rectum 50 (2007): 2158-67.

Rackelboom, T., Le, Strat, S., Silvera, S., Schmitz, T., Bassot, A., Goffinet, F., Ozier, Y., Beaussier, M., Mignon, A., "Improving Continuous Wound Infusion Effectiveness for Postoperative Analgesia after Cesarean Delivery." Obstetetrics and Gynecology 116 (2010): 893-900.

Rawal, N., "Local Infiltration Analgesia and other Multicomponent Techniques to Improve Postoperative Outcome – Are We Comparing Oranges and Apples ?" Regional Anesthesia and Pain Medicine 36 (2011): 417-20.